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The intelligent energy system infrastructure for the future

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The intelligent energy system infrastructure for the future

Water & Energy
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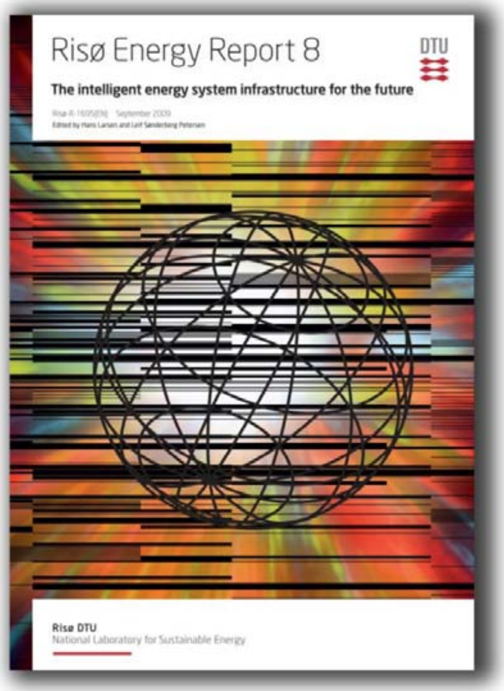
Risø Energy Report 8

The report is volume 8 in a series that began in 2002

- The report presents the need for the development of a highly flexible and intelligent energy system infrastructure which facilitates substantial higher amounts of renewable energy than today's energy system

- This is necessary to achieve the goals set up by IPCC in 2007 on CO_2 reductions

- The report presents a generic approach for future infrastructure issues on local, regional and global scale with focus on the energy system itself



- Written by researchers from DTU together with other Danish and International experts

- Based on the latest research results together with available international literature

The global energy scene

- Within the energy sector **energy security and climate change** are the two overriding priorities. This is especially true for industrialized countries and the more rapidly developing economies.

- Many developing countries, on the other hand, still face basic energy development constraints which give quite a different meaning to the concept of energy security.

- Today 1.6 billion people have no access to modern energy

The global economy

- The global economy has in recent years faced a number of changes and challenges.

- Globalization and free market economics have dominated the last decade, but the current financial crisis is rapidly changing the political landscape.

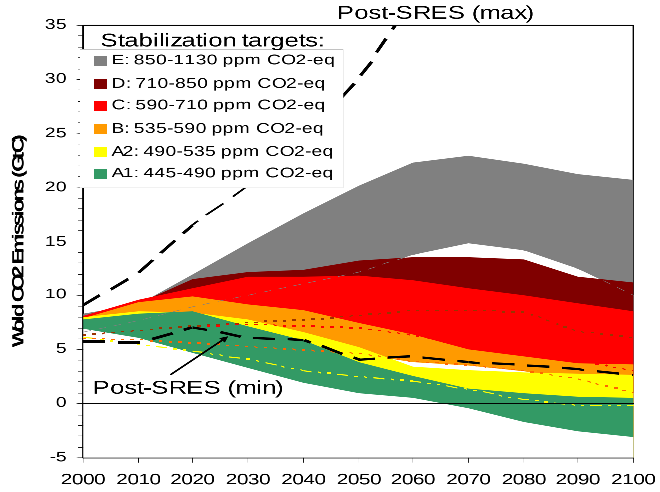
- The need to provide energy services with due respect to economic growth, sustainability and security of supply

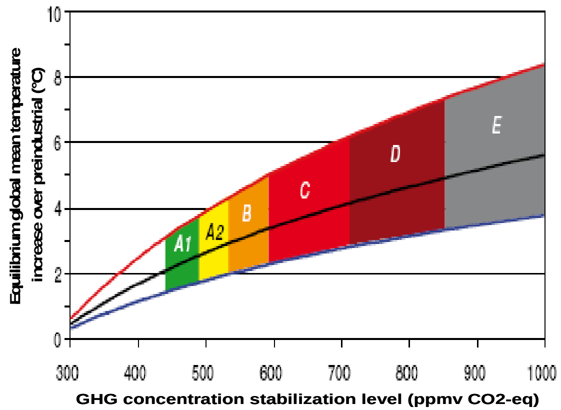
Climate change

- IPCC - 4. assessment report in 2007
- Nobel peace price
- COP15 in Copenhagen in December 2009

Climate Change:

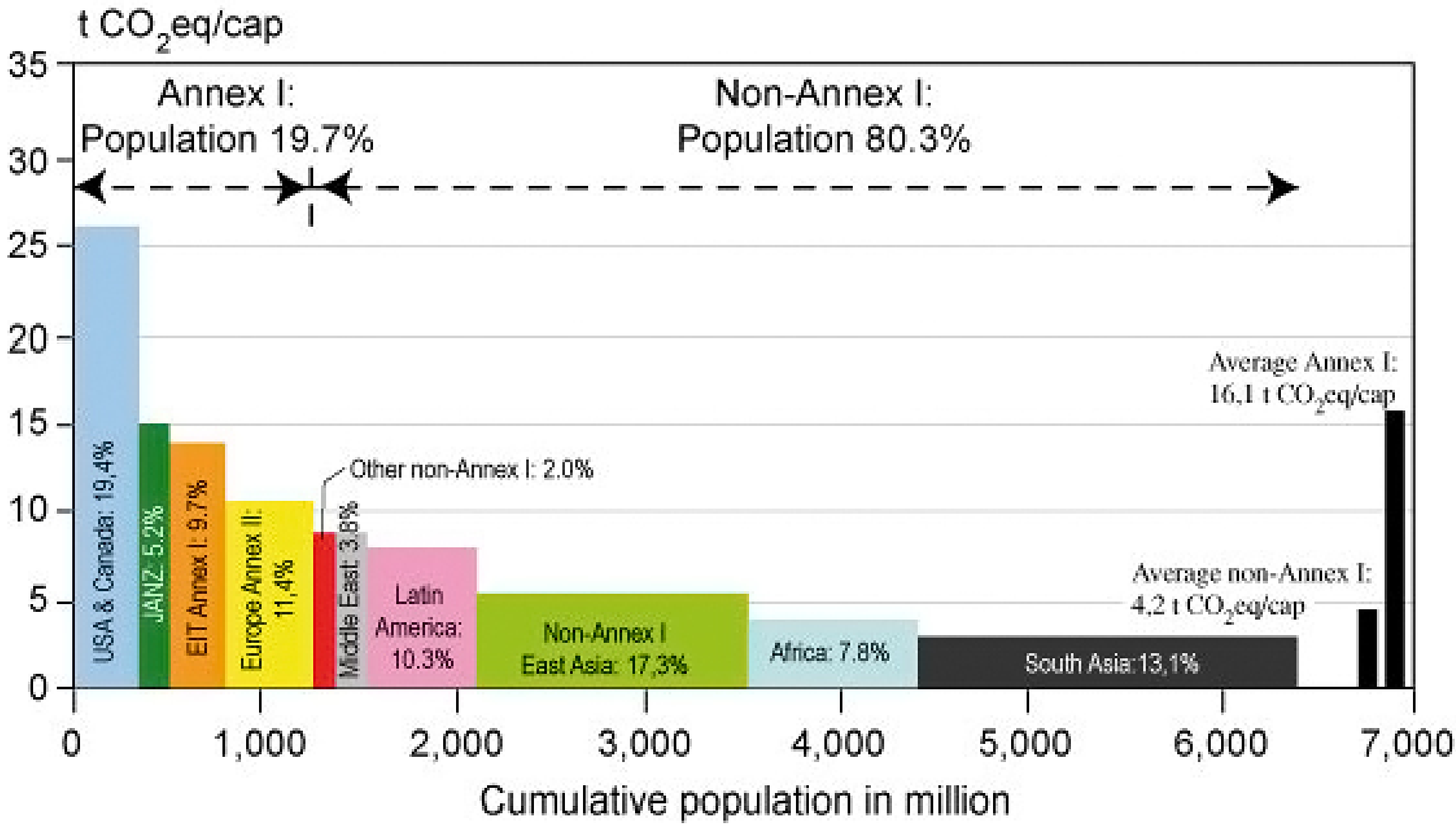
- The need to ensure a peak in CO_2 emissions before 2020 and at least a 50% reduction in the long run on a global scale e.g. in 2050 and later close to zero or even negative



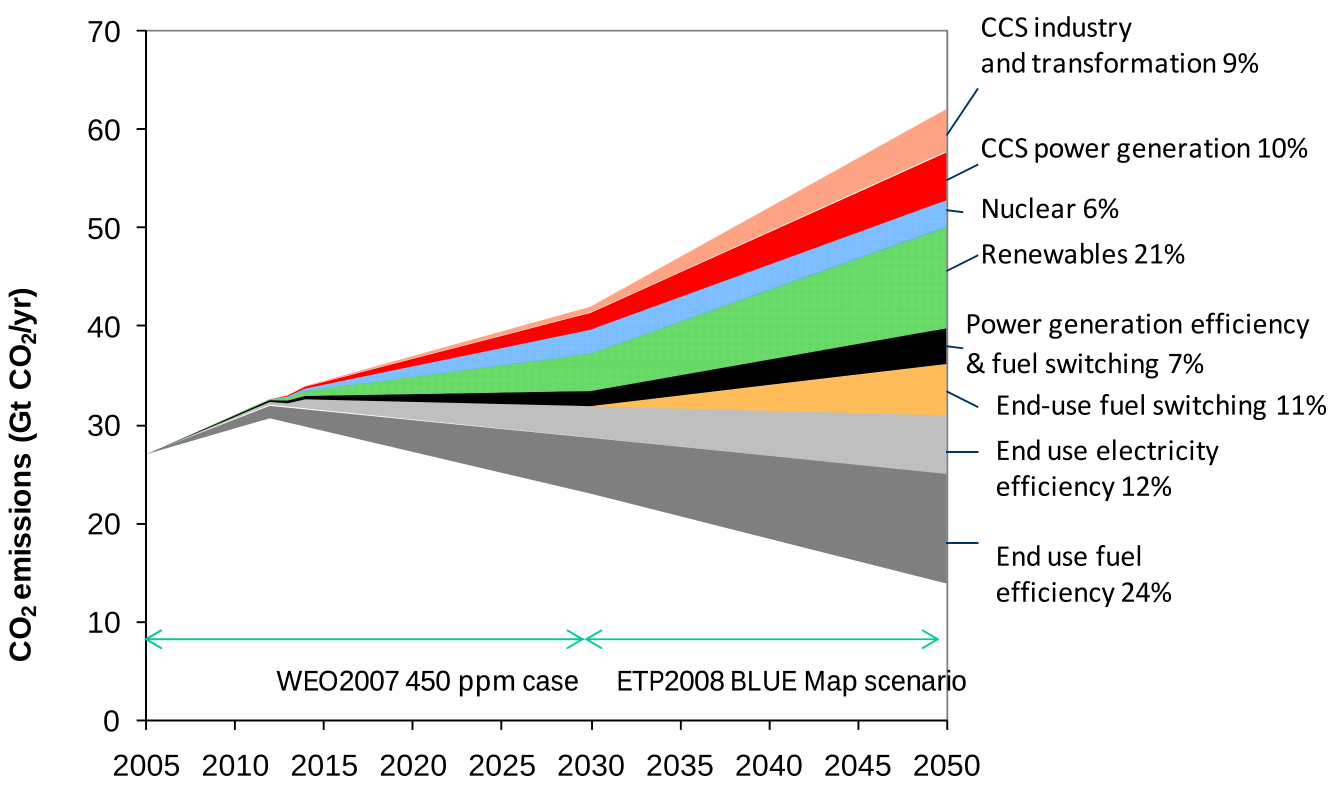


Source: IPCC 4 Assessment Report 2007

CO2 eq / cap IPCC AR4



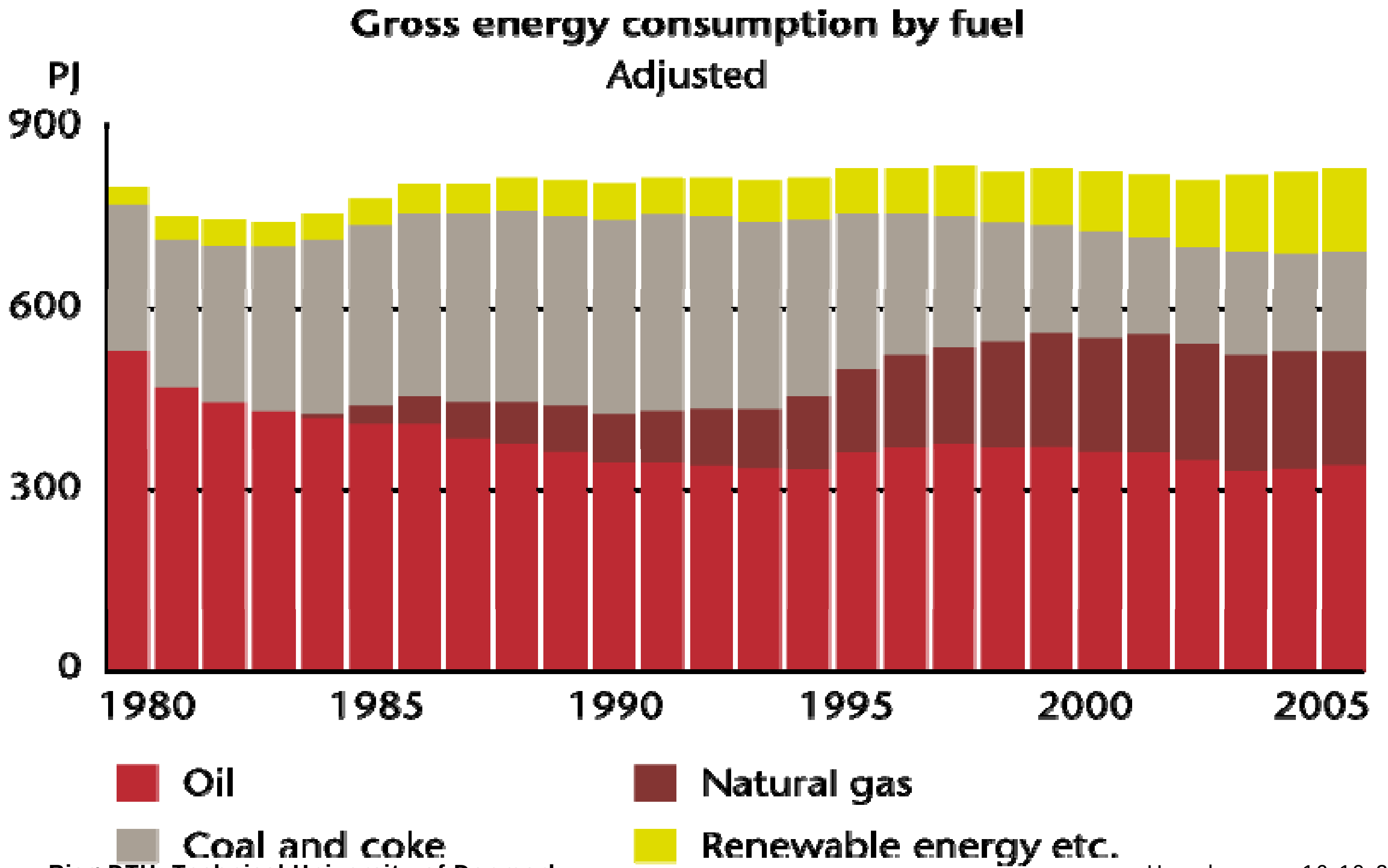
CO_2 emissions



Source: IEA

Danish energy consumption has been stable over the last 25 years

- Is it possible to continue ...?

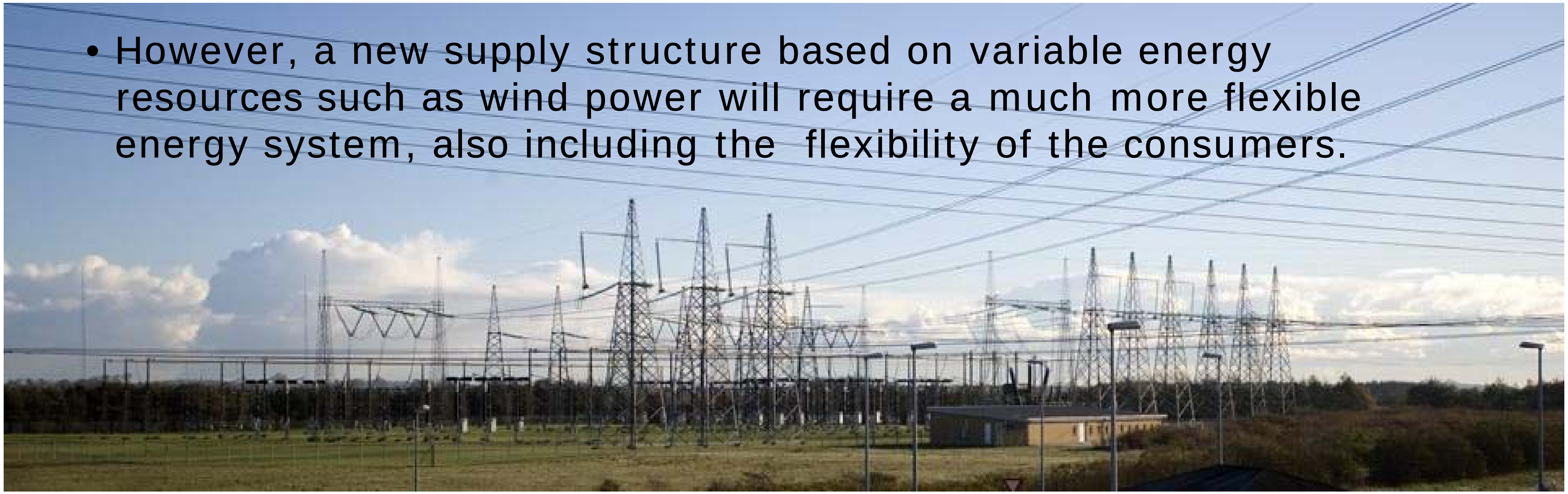


The energy system

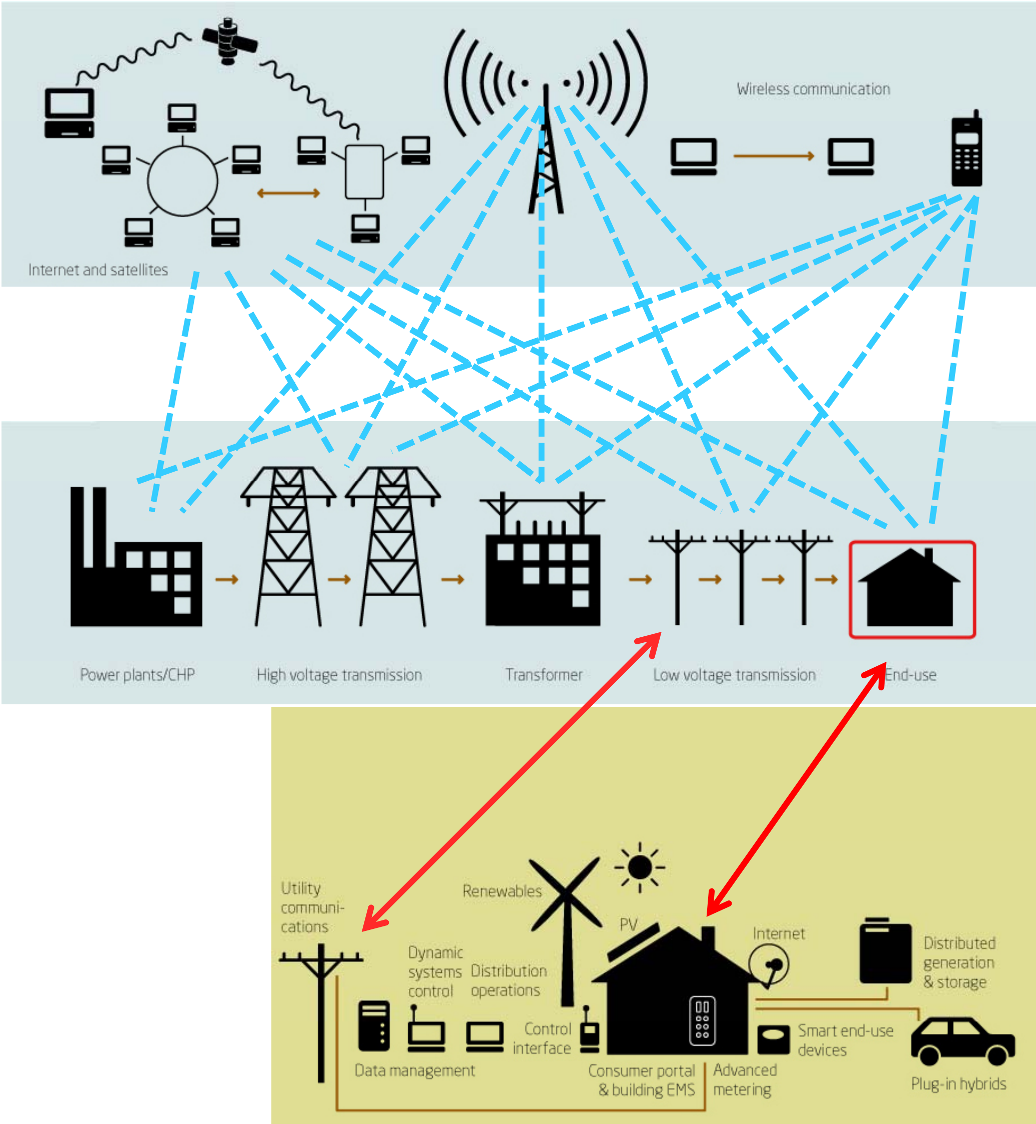
- Today’s energy system is the result of decisions taken over more than a century.

- This long-term development is reflected in the structure of the energy system, which in most cases was developed according to basic engineering requirements: energy is produced to meet the needs of consumers.

- However, a new supply structure based on variable energy resources such as wind power will require a much more flexible energy system, also including the flexibility of the consumers.



The future intelligent energy system



Information and Communication Technologies

+

Traditional power system structure

+

Distributed generation and efficient building and transport systems

=

The future intelligent energy system emerges

Structural changes in the power system

- The power system is currently undergoing fundamental structural changes.

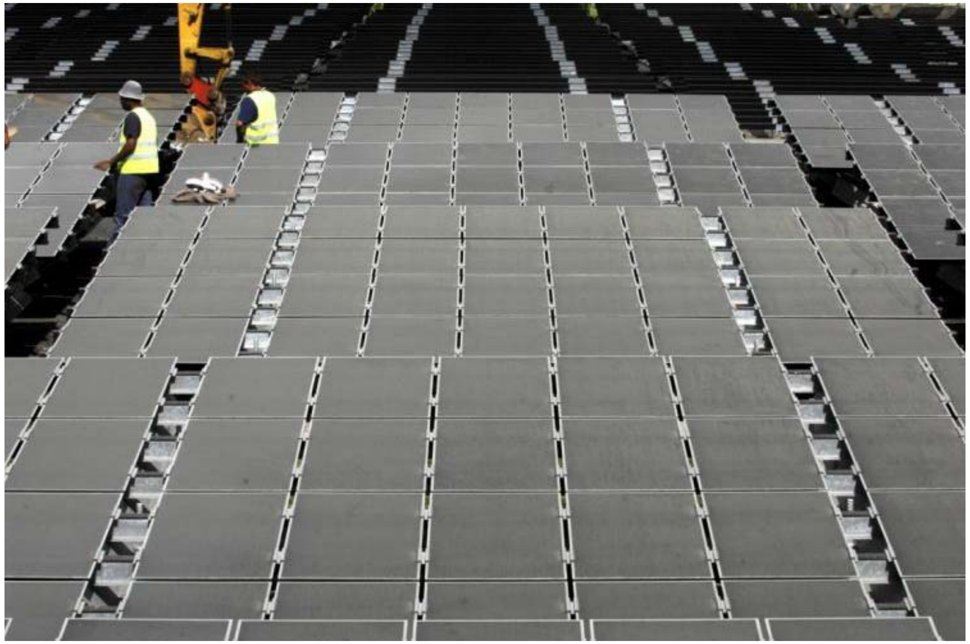
- The causes are:
  - the rapidly increasing amount of fluctuating renewable energy
  - the use of new types of production and end-use technologies.

Information and Communications Technology (ICT)

- Increased use of Information and Communications Technology (ICT)
- The rapidly increasing capabilities, and falling costs, of ICT open the way to two-way communication with end-users
- Making this one of the most important enabling technologies for the future power system.

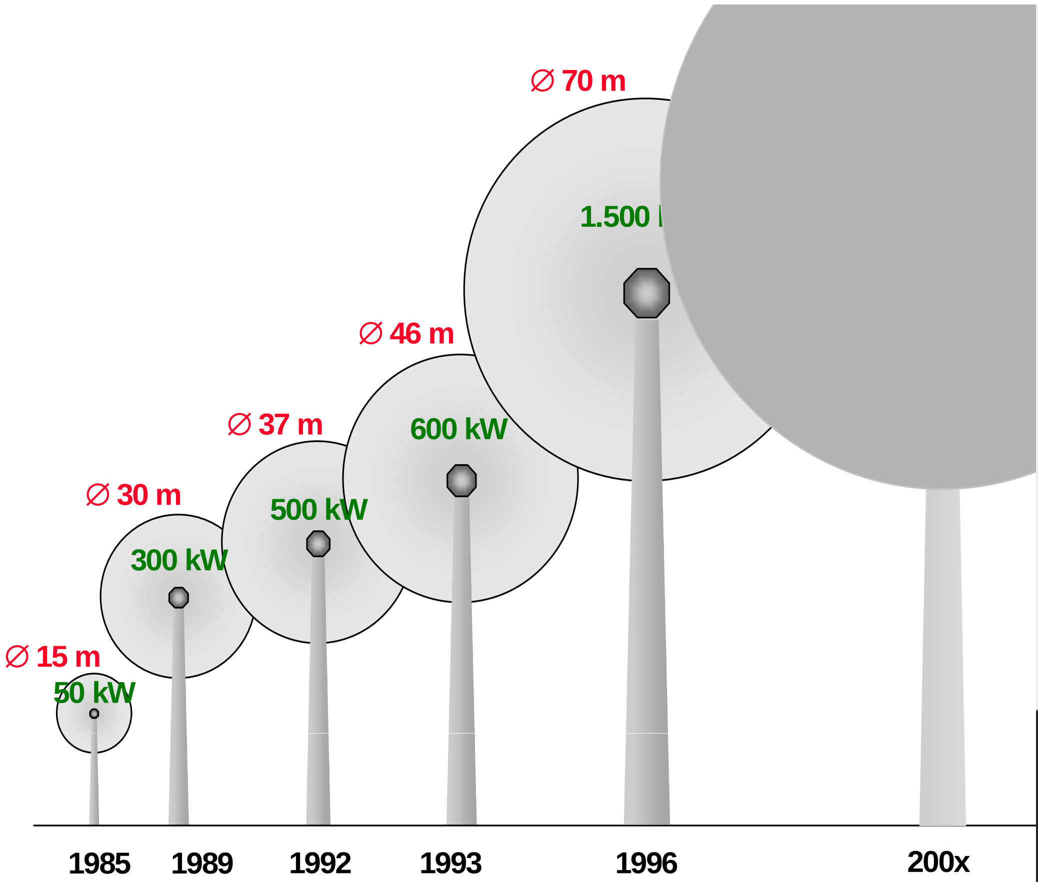
Renewable energy sources

- Renewable energy resources used to occupy an almost insignificant niche, are gradually expanding their role in global energy supply.
- Today the largest contributors are traditional biomass and hydropower
- “New renewables” such as photovoltaics, wind power, small-scale hydro, biogas and new biomass plays a minor role, but are expanding rapidly.

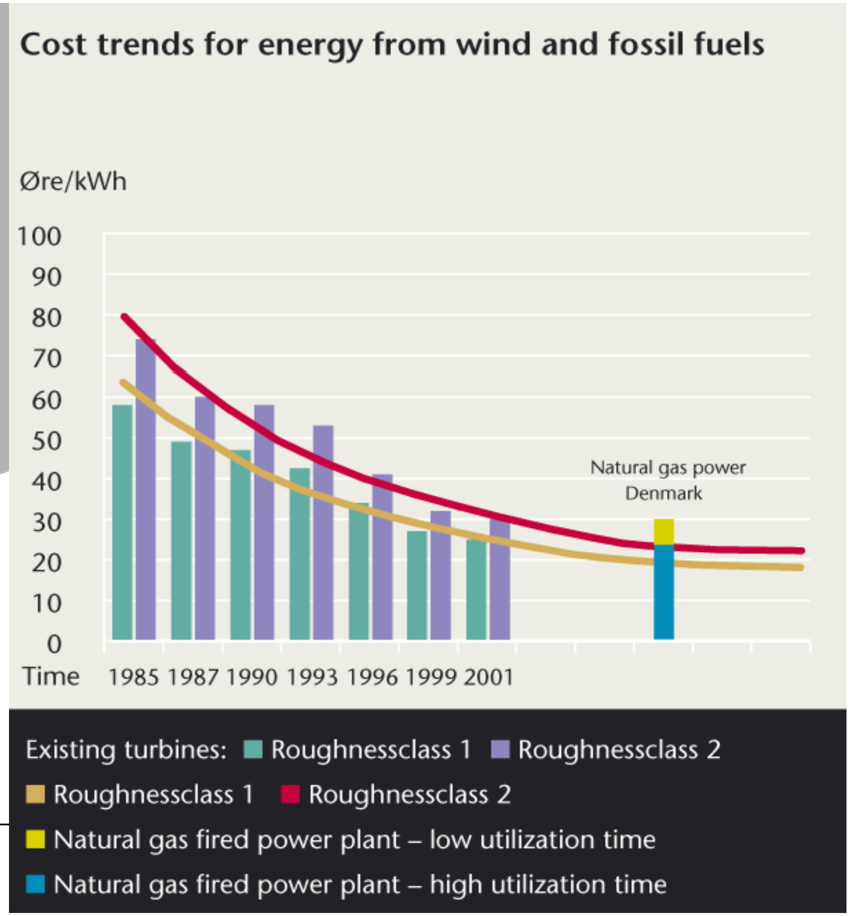


Wind energy

Development of wind turbines

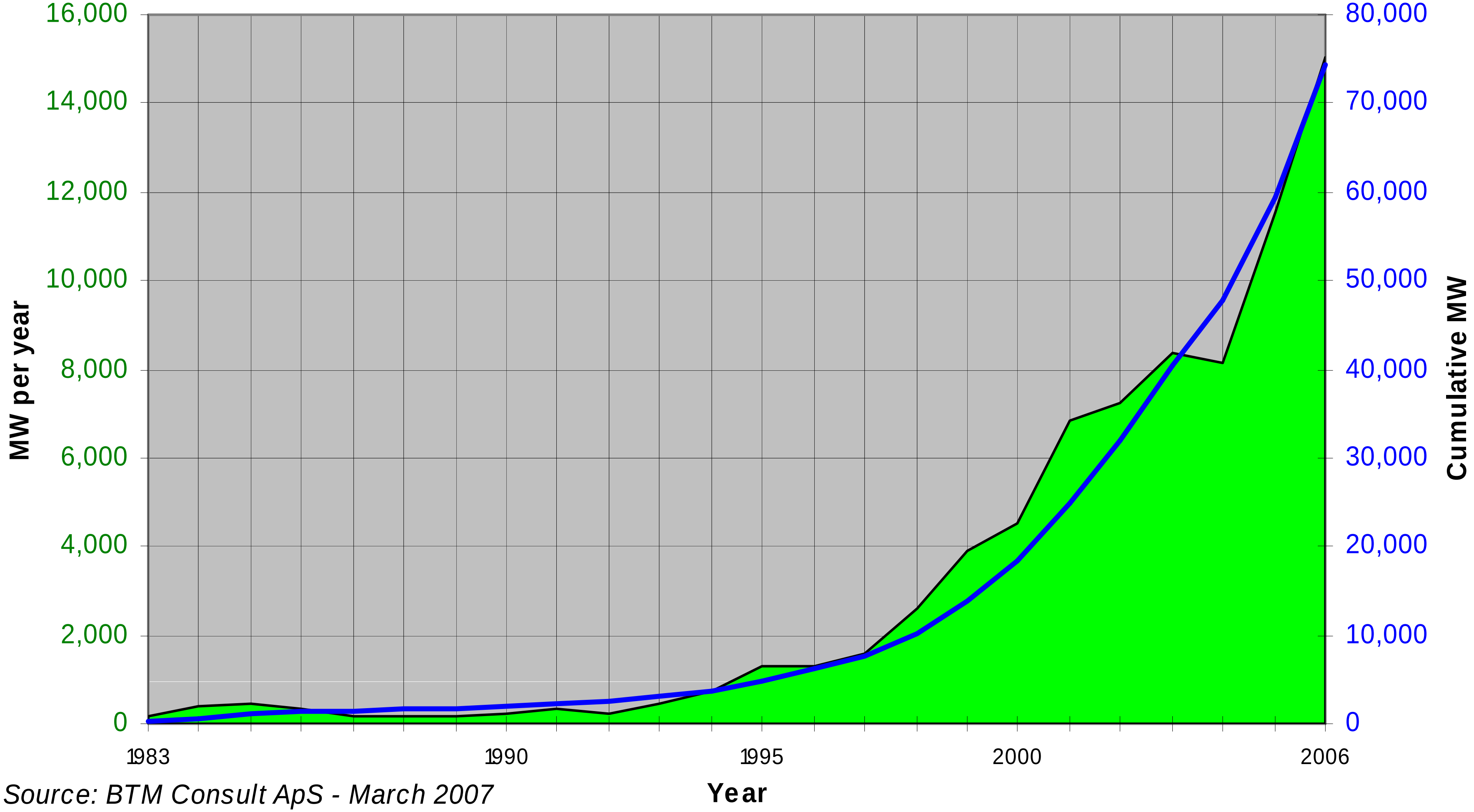


Cost of energy from wind and fossil fuels



Installed Wind Power in the World

- Annual and Cumulative -



Source: BTM Consult ApS - March 2007

Technology for sustainable energy supply - Bioenergy

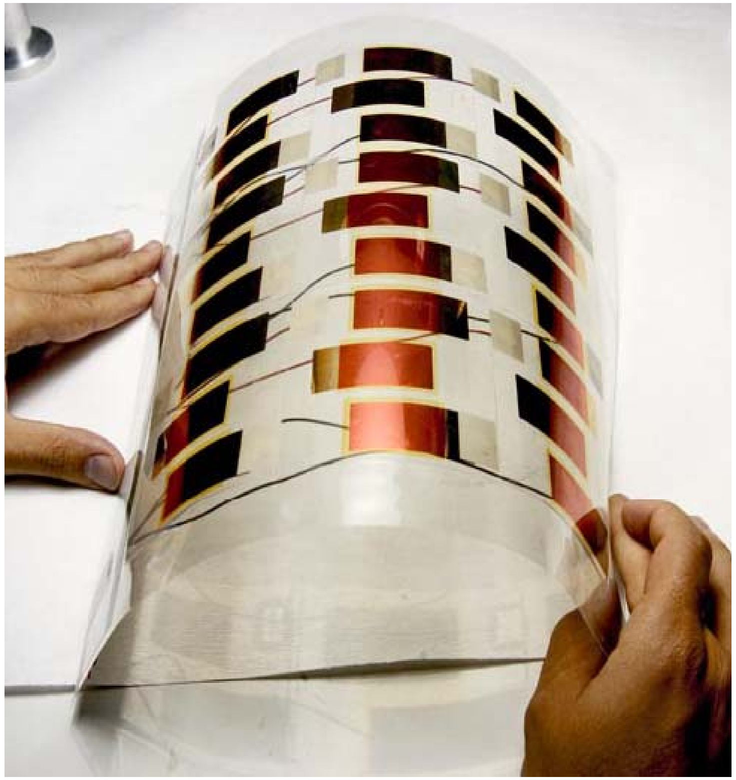
- Production and properties of biomass

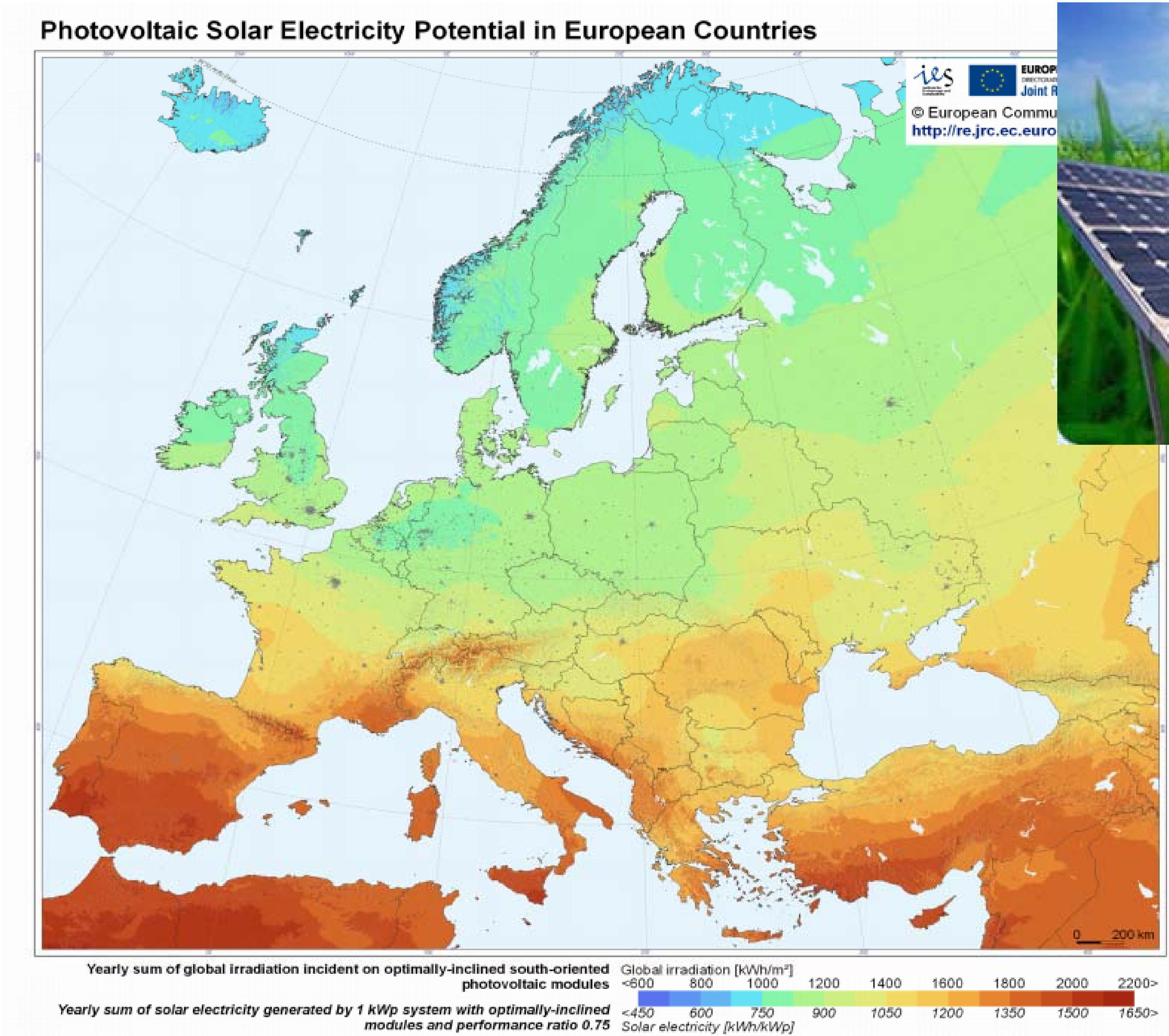
- Biomass conversion and co-production

- The production of
  2 generation bio-fuel from straw by means of an internationally unique method

Photovoltaics

- The market for photovoltaic's has grown at an average of more than 30% annually over the last 10 years
- Crystalline silicon remains the standard PV technology with a market share above 90%
- Although efficiencies of solar cells continue to rise, high cost remains the principal barrier to PV as a large scale energy producers
- Polymer solar cells may succeed where silicon has failed because they are cheap to make

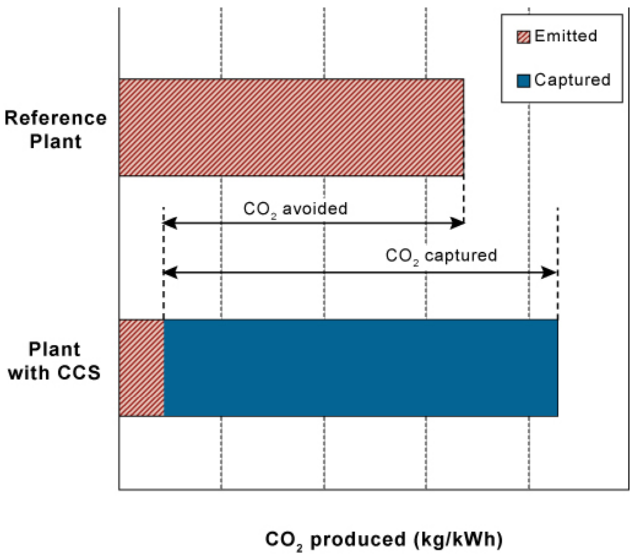


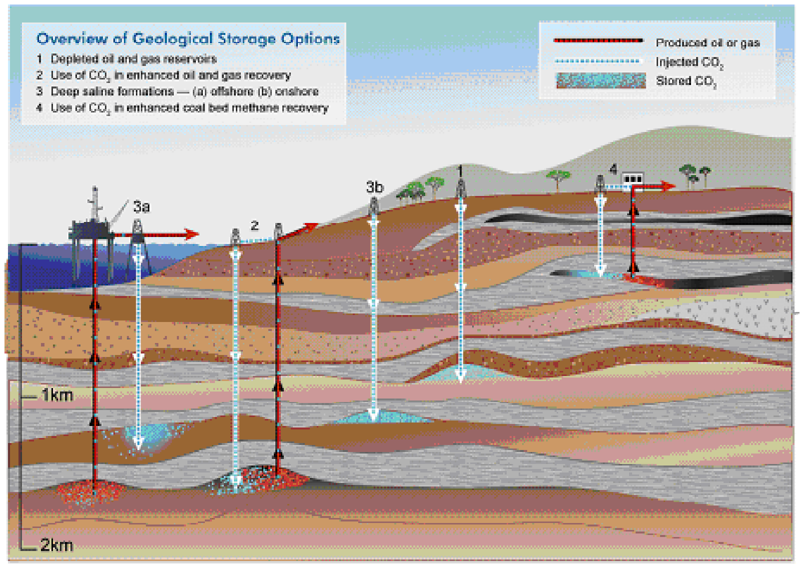


Different potentials in North and South

Carbon Capture and Storage - CCS

- Additional energy use of 10 - 40% (for same output)
- Capture efficiency: 85 - 95%
- Net CO_2 reduction: 80 - 90%
- Assuming safe storage





Storage

- Energy storage is needed in a future energy system dominated by fluctuating renewable energy depends on many factors:
  - the mix of energy sources,
  - the ability to shift demand,
  - the links between different energy vectors, and
  - the specific use of the energy.
- Storage costs and energy losses need to be considered.

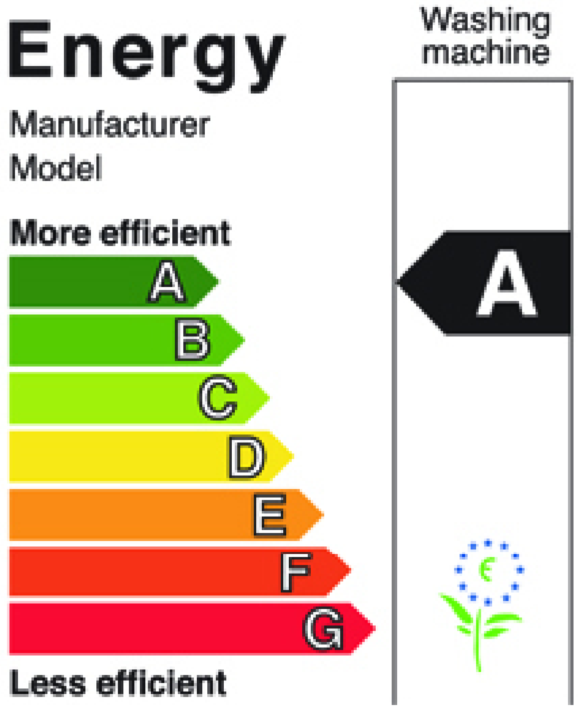
Transport sector

- Modern transport depends heavily on fossil fuels. Ways to reduce emissions from transport are to shift to renewable or at least CO_2-neutral energy sources, and to link the transport sector to the power system.

- Achieving this will require new fuels and traction technologies, and new ways to store energy in vehicles.

Efficiency improvements

- High emphasis on efficiency improvements in both industry and private households changing demand patterns are going to generate new challenges to system operators and utilities.



Self sufficient costumers

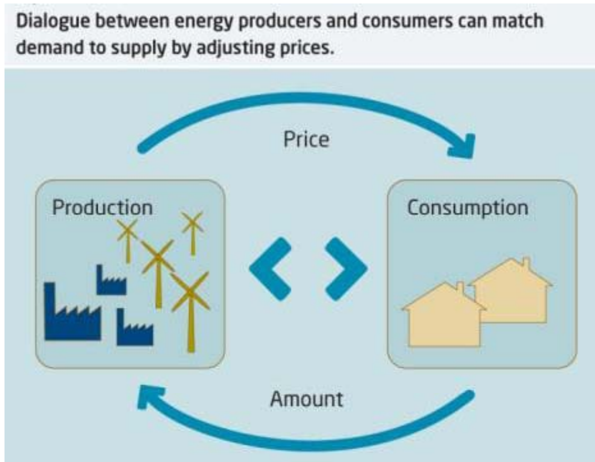
- The customers are becoming increasingly independent as they in long periods can be self-sufficient with energy by producing some of their limited need for electricity and heat by solar collectors, fuel cells etc.
- In short periods of time they are expecting the system to supply all their needs.

Volatile hourly prices

- A future electricity system with a considerable amount of fluctuating supply implies quite volatile hourly prices at the power exchange.

- Persuading customers to react to hourly prices would improve market efficiency, reduce price volatility, and increase welfare.

- Increasing the proportion of wind power in the system increases the benefits to consumers of acting flexible.



Flexible and intelligent energy system

Prerequisites:

- effectively accommodate large amounts of varying renewable energy;
- integrate the transport sector through the use of plug-in hybrids and electric vehicles;
- maximise the gains from a transition to intelligent, lowenergy buildings; and
- introduce advanced energy storage facilities in the system.

A high share of fluctuating energy sources

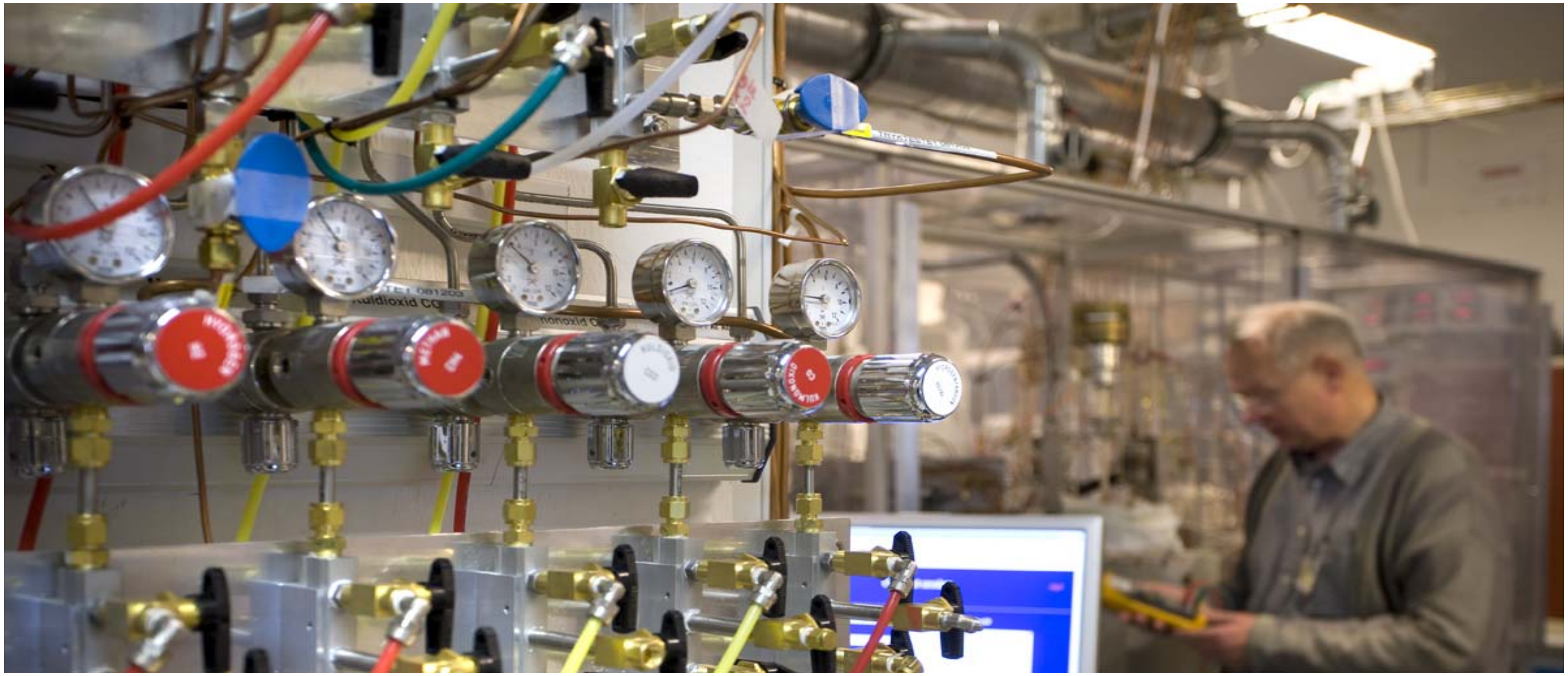
- Long-term targets for renewable energy deployment and stable energy policies are needed in order to reduce uncertainty for investors.
- A mix of distributed energy resources is needed to allow system balancing and provide flexibility in the electricity system.
- Electric vehicles, electric heating, heat pumps and small-scale distributed generation, such as fuel-cell-based microCHP, are promising options.

Long term development

- Apart from development of the future highly flexible and intelligent energy system infrastructure which facilitates substantial higher amounts of renewable energy than today's energy system
- there is also the need for development of new sustainable supply and end-use technologies for the period after 2050 where CO_2 emissions should be almost eliminated

Long-term research

- Hence, there is a strong need to pursue long-term research and demonstration projects on new energy supply technologies, end-use technologies, and overall systems design. Existing research programmes in these areas should be redefined and coordinated so that they provide the best contribution to the goal of a future intelligent energy system.



Thank you for your attention